

## Solutions for location of emergency calls in Sweden

This document describes the different solutions applied by the emergency communications operated by the Emergency Service in public electronic communications networks in Sweden for the support of location of emergency calls to the emergency number 112.

## Reference

ITS Report 29

## Keywords

AML, eCall, Location, Positioning, 112-app

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## 1. Scope

The purpose of this document is to provide understanding of how location has been implemented in the Swedish public electronic communication networks for emergency calls.

The document describes the different solutions applied by the emergency communications operated by SOS Alarm<sup>1</sup> in public electronic communication networks in Sweden for the support of location of emergency calls to the emergency number 112.

The document initially gives a historic overview when different solutions were introduced into public electronic communications networks and then detailed technical descriptions of the different solutions with references to applicable technical documentation highlighting:

- Technical Specifications
- Conformity to Legal Requirements

## 2. References

[1] SS636394, 2004	Positioning of Mobile Terminals at Emergency Calls
[2] Directive 2002/22/EG, 2002	Universal Service Directive
[3] Directive 2009/136/EG, November 2009	Revision of Universal Service Obligation Directive
[4] ITS ApG 21 v5, July 2019	Routing of calls to the emergency number 112 using the Identification Plan of Municipalities
[5] EENA AML, 2016	Advanced Mobile Location (AML) Specifications & Requirements
[6] Alias MS-ISDN	SOS Alarm document describing Alias A-numbers.
[7] ETSI TR 103 393, 2016-03	EMTEL: Advanced Mobile Location for emergency calls
[8] PTSFS 2005:3, 16 maj 2005	Post- och telestyrelsens föreskrifter om skyldighet att lämna ut abonnentuppgifter
[9] PTSFS 2009:1, 10 juni 2009	Föreskrifter om ändring i Post- och telestyrelsens föreskrifter (PTSFS 2005:3) om skyldighet att lämna ut abonnentuppgifter
[10] IETF RFC 6442, December 2011	Location conveyance for SIP
[11] RFC 3261, June 2002	Session Initiation Protocol
[12] ITU-T Q761 - 765	ISDN User Part
[13] SOS Alarm IP/SIP Interconnect Specification 2018-05-23	Specification for termination of emergency calls using SIP between directly connected voice service providers and SOS Alarm
[14] ITS 24 V1 2006-12-06	Guidelines for calls to emergency numbers 112 and 90 000 in Sweden
[15] ITS ApG 25 V3 2020 -06-23	Guidelines for emergency communication to emergency number 112 in Sweden using SIP
[16] (EU) 2018/1972	Directive on establishing the European Electronic Communications Code
[17] ETSI TS 103 625	Transporting Handset Location to PSAPs for Emergency Calls - Advanced Mobile Location

<sup>1</sup>SOS Alarm is acting as the emergency service provider according to an agreement with Swedish government.

### 3. Terms and definitions

#### 3.1. AML SMS

A regular SMS oppressed from being stored in "sent list".

#### 3.2. Application data message

In this document defined as Information sent over the data channel. Requires that the terminal can establish a data connection and not using SMS technology.

#### 3.3. Authenticated mobile terminal

A mobile terminal correctly logged into and registered to a mobile network.

#### 3.4. Calling Party Number

The telephone number (A-number) of the originator of the call.

#### 3.5. Emergency roaming mobile terminal

A mobile terminal with SIM-card where the mobile terminal is located in a network where roaming agreement for the subscriber's operator is not valid.

#### 3.6. Internet Protocol (IP)

In this Application Guide IP refers to both IPv4 and IPv6.

#### 3.7. Location information

Information of position based on coordinates, polygon or geodetic address (e.g. street address).

#### 3.8. Location number

Parameter in ISUP Indicating network of origination of a call. No equivalence in SIP.

#### 3.9. SIM-less mobile terminal

A mobile terminal without SIM-card.

## 4. Abbreviations

2G	Second generation mobile system, GSM
3GPP	3rd Generation Partnership Project
AML	Advanced Mobile Location
Android	Google Operating System
EENA	European Emergency Number Association
GNSS	Global Navigation Satellite System
GSM	Global System for Mobile Communications
HLR	Home Location Register
IETF	Internet Engineering Task Force
IMSI	International Mobile Subscriber Identity
iOS	iPhone Operating System
IP	Internet Protocol (IPv4/IPv6)
ISUP	ISDN User Part
LEK	Lagen om elektronisk kommunikation (Electronic Communications Act)
MAC	Media Access Control
MAP	Mobile Application Part
MIC	Municipality Identification Code
MLP	Mobile Location Protocol
MSD	Minimum Set of Data
NTP	Network Termination Point
PSAP	Public Safety Answering Point
SIP	Session Initiation Protocol
SIM	Subscriber Identity Module
SMS	Short Message Service
SS7	Signalling System No 7
SSID	Service Set Identifier
TPS	Third Party Service (eCall)
TPSP	Third Party Service Provider
TSD	TPS-eCall Set of Data
UE	User Equipment
VIN	Vehicle Identification Number

## 5. Development of location of calls to the emergency number 112 in Sweden

The emergency number 112 was introduced in Sweden 1 of July 1996 in parallel with the existing emergency number 90 000. SOS Alarm has the responsibility to be call taker for emergency calls from the public electronic communication networks and to initiate emergency resources like ambulance, fire brigade and police.

To fulfill this task SOS Alarm operates a call taking system which is the interface between the public electronic communication networks and SOS. [14]

When public electronic communication networks were modernized with signaling system number 7 (SS7) during the 1980s it became possible to transfer the Calling Party Number which then became visible for the SOS answering point. This created the possibility to retrieve the geographic address of the caller by making a query to Televerkets<sup>2</sup> customer system/address database.

Address information is since 2005 provided through agreement between SOS Alarm and a supplier of directory information for delivery of address according to regulation<sup>3</sup>.

Until the beginning of 1980s there existed no mobile telephony which meant that the address database provided a covering service, i.e. addresses for all subscribers where available.

Mobile telephony grew quickly during the 1990s after the introduction of second-generation mobile systems based on GSM. It then became obvious that location of mobile terminals should be possible since the 112-service quality otherwise would deteriorate.

2002 the revised EU-directive concerning Universal Service Obligation [2] was decided which among other things required "Provision of information of call origination". Then work in Sweden started to develop a standard for location of mobile terminals. The specification was ready 2004.[1]

The introduction of support for location in the mobile networks took several years. Reasons for that were among others the fact that SOS Alarm had to pay for each location request. This led to a requirement of the possibility to identify the originating network of a 112-call which in its turn had impact on the interface between the public electronic communication networks and SOS<sup>4</sup>.

All four mobile networks<sup>5</sup> had introduced support for location of mobile terminals 2007. The requirement concerning what call cases should be supported was limited to what was technically feasible according to the EU-directive. This meant that authenticated terminals were considered being part of the obligation while emergency roamers and SIM-less calls were not.

The EU directive was revised in 2009, omitting the feasibility limitation, since it was considered technically feasible to locate non-authenticated terminals. In Sweden work was started to find out solutions. By then the possibility to require a common solution for all mobile networks had been taken away which lead to each mobile network introducing unique solutions. Depending on the complexity, specifically for SOS, the work took several

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<sup>2</sup> Televerket is the former incumbent operator in Sweden – now called Telia Company.

<sup>3</sup> PTSFS 2005:3, revised by PTSFS 2009:1.

<sup>4</sup> If SOS has no knowledge of originating network for a 112-call the location request would have to be based on broadcast to all networks resulting in much higher costs for SOS.

<sup>5</sup> Tele2, Telenor, Telia, Tre.

years and was finalized as late as 2015. The European Union stated in the EU ruling 2019-09-05 that locating SIM-free terminals, if the emergency call is made from such a terminal, is mandatory<sup>6</sup>.

During 2018 a discussion was started concerning the creation of a 112 Application designed by SOS Alarm able to provide GNSS-based location information on 112-calls. A 112 App was launched by SOS Alarm in the middle of 2019 under the name "112-app". It works when the subscriber opens the application on the terminal and presses "112-app". Then the emergency call is established and the location coordinates are sent to SOS in an application data message. This gives much better accuracy concerning location since it is coordinates for a certain location and not an area which is the case at base station location where an area is shown. The method provides User Provided Location Information depending on that the terminal provides correct information.

Since 2014 the organization EENA has worked with the development of a functionality called Advanced Mobile Location, AML. It shall be included in the operating system of the terminal. When an emergency call is made AML automatically delivers location in a AML SMS.

AML functionality is triggered by an emergency call (which is progressed normally by the terminal and the network), and is designed to supplement the basic network location with GNSS or Wi-Fi generated location information. The limitations in GNSS or Wi-Fi availability for the terminal and the time required to acquire location using GNSS must be considered. The method provides User Provided Location Information depending on that the terminal provides correct information.

During the spring 2019 SOS Alarm started discussions with the mobile operating system suppliers Apple and Google concerning activating AML in the Swedish mobile networks. AML was launched in all four mobile networks after the summer 2019. The support for AML will be mandatory within the European Union for all mobile operating system suppliers from March 17, 2022<sup>7</sup>.

Since a couple of years SOS has worked with specifications for IP-interconnection to the public electronic communication networks [15]. This is an adaptation to what is used within the public electronic communication networks and also an opening for new IP-based services. Concerning location, the IP-interface opens for location information provided in the call establishment phase (Call Set-Up) based on IETF 6442 [12]. This means that the location of the mobile terminal will be available to the emergency call taker simultaneously with and in the incoming emergency call.

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6 Case C-417/18.

7 COMMISSION DELEGATED REGULATION (EU) 2019/320, December 12:th, 2018.



## 6. Location information which can be provided at emergency calls

### 6.1. Location based on address

Location of a fixed subscriber is done through the relation between the geographic address of the Network Termination Point and the telephone number used at the NTP. This information is stored in an address database. Electronic communications service providers have an obligation to deliver information on address and telephone number to actors providing directory enquiry services. This is a regulatory requirement<sup>8</sup>.

When a fixed or mobile subscriber calls the emergency number 112 the Calling Party Number is always visible to the emergency call taker. This also applies to restricted numbers. Using the received Calling Party Number (A-number) SOS sends a query to the address database which responds with the address connected to the telephone number.

### 6.2. Location of fixed terminals

On calls from fixed subscriptions the emergency call taker receives the following location information.

- The municipality of call origination [4].
- Geographic address retrieved from the address database using the calling subscriber's telephone number.

The municipality information always comes. The geographic information is delivered if it is registered in the address database.

### 6.3. Location of mobile terminals

On calls from mobile terminals the emergency call taker receives the following location information.

- The municipality where the base station is located.
- Geographic address retrieved from the address database. Often the invoice address for the subscription.
  - This address can be totally different from the place where the mobile terminal is located.
  - This information can be lacking, e.g. for unregistered prepaid subscriptions.
- The coverage area of the base station shown on a map.
- Geographic coordinates extracted from GNSS or Wifi carried in the AML SMS<sup>9</sup> provided by the terminal.
- Geographic coordinates extracted from GNSS from the 112-application "112-app" provided by the terminal if the function has been invoked by the subscriber.
  - These geographic coordinates will come only if the 112-application is used.
  - If the 112-application is used, the AML SMS will also be sent (if AML is supported by the mobile terminal SW) since this is initiated by the dialing of the emergency number.

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<sup>8</sup> PTSFS 2009:1 Föreskrifter om ändring i Post- och telestyrelsens föreskrifter (PTSFS 2005:3) om skyldighet att lämna ut abonnentuppgifter.

<sup>9</sup> See chapter 11.

6.4. The accessibility of the information

- The municipality information is always available both for fixed and mobile calls.
- The base station coverage area is always available for mobile calls.
- The address information is available if the subscription (both fixed and mobile) is registered at an address.
- Location information from AML is available to the emergency call taker if the mobile terminal is authenticated in a network and if the terminal supports AML and provides the location information correctly.
- Location information retrieved from the 112-application is available if the subscriber has used the application, if data-connection is established for transfer of the 112-application data message and if the terminal provides the location information correctly.

## 7. Presentation to the Emergency Call Taker

Address and municipality information is displayed on the emergency call taker’s screen.

The location information is displayed on a screen showing a map. If the base station coverage area, 112-application data message and AML SMS all are available, only the information with the highest priority in the system is shown on the map. The emergency call taker can manually activate display of information with lower priority.

Priority order

- I. AML SMS coordinates
- II. 112-application coordinates “112-app”
- III. The base station coverage area

The reason not to show more information simultaneously is that AML or the 112-application coordinates can be situated outside the base station coverage area which might lead to confusion for the emergency call taker.

## 8. Location using Municipality Identity

To make location of emergency calls in Sweden possible the country has been subdivided in areas, normally municipalities. Each municipality is assigned a code indicating if the call comes from a fixed telephone or mobile terminal in the municipality concerned. These codes are described in the Municipality Identification Plan. [4]

When a subscriber dials 112, the network assigns a routing prefix and the correct municipality code, see below.

The subscriber dials	112
The network adds routing prefix and municipality code	379 112 XYZ

Where

379	Routing prefix
112	The emergency number
XYZ	Municipality Identity Code (MIC)

Example

379 112 142	Emergency call from fixed network in the municipality Åre
379 112 542	Emergency call from mobile network in the municipality Åre

When an emergency call reaches SOS Alarm the municipality identity is displayed in text for the emergency call taker. In the case above the text "Åre" is shown.

The municipality information is also used for making it possible to route to the PSAP responsible for a certain area and also to inform which type of access the call originates from. If it is a mobile origination the retrieving of location information is automatically initiated.

### 8.1. Special Municipality Codes

There exist call cases where it is not possible to decide which municipality code should be assigned. One such case is calls from IP based telephony. For these cases special codes are used where the emergency call taker can see that it is a call from an IP based telephony line.

Below examples of codes from the Municipality Identification Plan [4] used for other call cases.

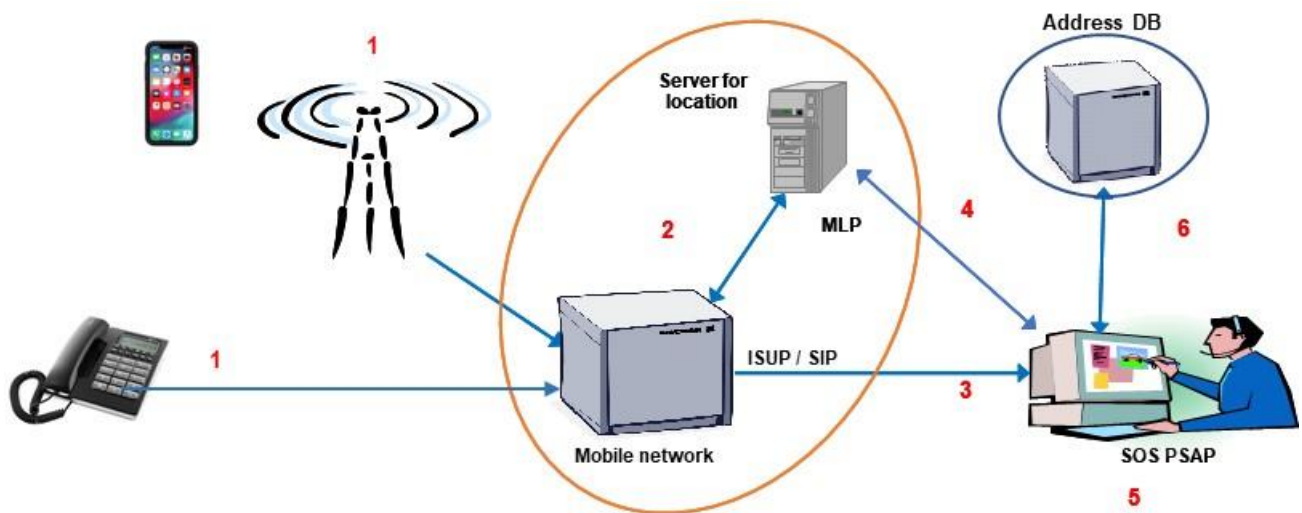
Geographic area or type of call	Service type	MIC
National Codes for IP-based fixed or mobile telephony passing gateway in Norrland	IP-based telephony	485
National Codes for IP-based fixed or mobile telephony passing gateway in Svealand	IP-based telephony	486
National Codes for IP-based fixed or mobile telephony passing gateway in Götaland	IP-based telephony	487
National Codes for IP-based fixed or mobile telephony passing gateway in Stockholm	IP-based telephony	489
National Codes for IP-based fixed or mobile telephony passing gateway in Västra Götaland	IP-based telephony	490
National Codes for IP-based fixed or mobile telephony passing gateway in Skåne	IP-based telephony	491
National Codes for IP-based fixed or mobile telephony passing gateway in Sweden	IP-based telephony	492
Test call from PSTN, ISDN or IP-based fixed telephony originating in Sweden.	Test	493
Calls to Emergency Information Number 11313 if accessed from abroad	Any telephony service	494
Satellite calls	Satellite	497
National Error Code for Mobile Telephony	Mobile Networks	498
National Error Code for Fixed Telephony	Fixed networks	499

## 9. Location using Network Termination Point or invoice address

When a subscriber signs a subscription, the address is registered at the electronic communications service provider. This can be the geographic address of the Network Termination Point or an invoice address. For fixed telephony it is usually the NTP but for mobile telephony and IP based telephony normally the invoicing address.

The registered information is regularly transferred to companies delivering directory enquiry services according to regulation, PTSFS 2009:1 [9].

SOS Alarm has signed an agreement with a directory enquiry services company and can fetch address information through a query to the address database using the received A-number as identifier.



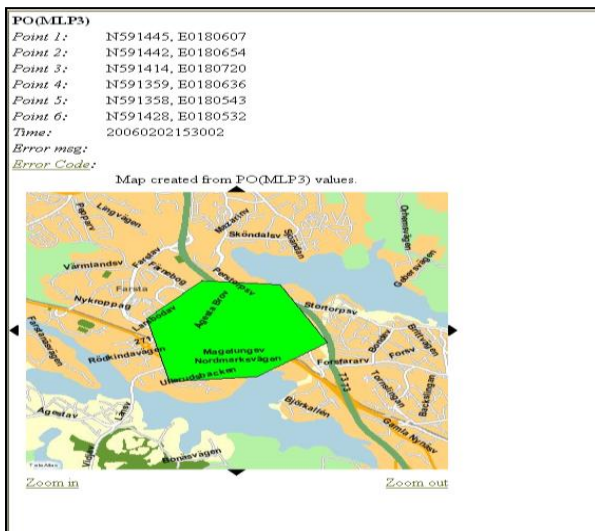
1. Fixed or mobile subscriber makes a 112-call
2. If mobile call: the location information is prepared.
3. The call reaches the emergency call taker.
4. The position of the mobile terminal is transferred to the emergency call taker.
5. The emergency call taker sees the telephone number and location (if mobile call).
6. Using the telephone number, the geographic address is retrieved from the address DB.

SOS has access to the address of all numbers including addresses of restricted numbers.

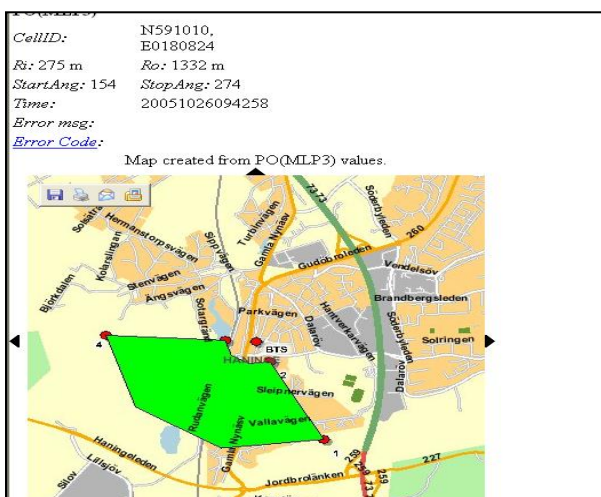
## 10. Base station location (Cell-ID)

On location based on the geographic coverage area of the base station the mobile network sends coordinates of an area where, with a likelihood of e.g. 90 %, the mobile terminal is situated inside the area. This means that the terminal can be outside of the area which is displayed to the emergency call taker. For this method to work properly, it requires the mobile operators to update after network changes as for example when new base stations are installed, or existing ones are relocated.

Below examples of coverage from 2G and 3G base stations.



Picture 1: Coverage 3G-cell

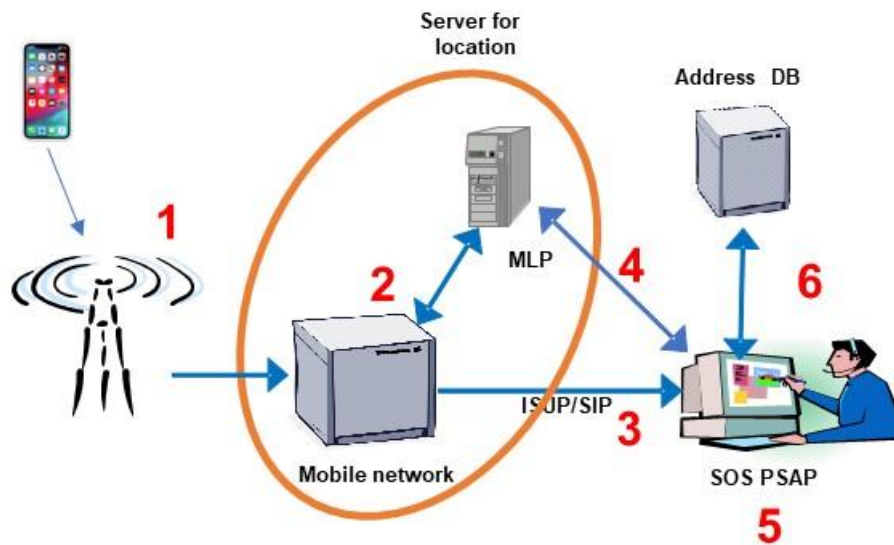


Picture 2: Coverage 2G-cell

### 10.1. Base station location for handsets with authenticated SIM-cards

On a 112-call from a terminal with an authenticated SIM-card the location information is identified on the received A-number. Without that information it would be impossible to know which call the incoming location information refers to.

Below a description of the procedure.



Below the procedure.

1. A 112-call from an authenticated terminal.
2. The call is routed through public communications network to a PSAP.
3. The emergency call taker would like to know the location and asks through pressing a button on the screen, (This can be automatic).
4. The SOS Alarm client for location sends a query to the right mobile network or does a broadcast to all networks.
  - a. The first part of the parameter Location Number<sup>10</sup> received in the incoming call identifies the network.
  - b. The mobile network replies by sending the location information. This information may also be pushed from the mobile network without SOS to send a request.
5. This is displayed on a screen at the emergency call taker.
6. A query is sent to the Address Database and the registered address of the caller is returned (If registered).

<sup>10</sup> Location Number is an ISUP parameter.

## 10.2. Base station location for handsets with non-authenticated SIM-cards

Handsets with non-authenticated SIM-cards are those emergency roaming or without SIM-card. On such calls the mobile network must assign a temporary A-number (also named Alias number) since the incoming location information is related to the incoming call on the A-number<sup>11</sup>. The four mobile networks in Sweden applies different solutions concerning creation of the temporary A-number. This has led to four different solutions which has been a challenge for SOS Alarm.

The procedure is similar to the procedure described in chapter 10.1.

## 11. Location with Advanced Mobile Location (AML)

AML is a function which is implemented in the operating system of the mobile terminal. The roll out of the function is done through update of the terminal's operating system which is controlled by the developer of the operating system, currently Android for Google and iOS for Apple. Furthermore, the terminal must be above a certain level of software version and the same applies to the operating system version. AML only works when the terminal is authenticated since it must send SMS which is only possible in authenticated mode.

### 11.1. Functions for AML in the mobile

GNSS normally offers the best location information but can be slower than other methods. On the other hand, Cell-ID based information is quick but offers less accuracy concerning the location.

As soon as an emergency call is initiated the mobile phone shall automatically activate the following functions if they are not already activated.

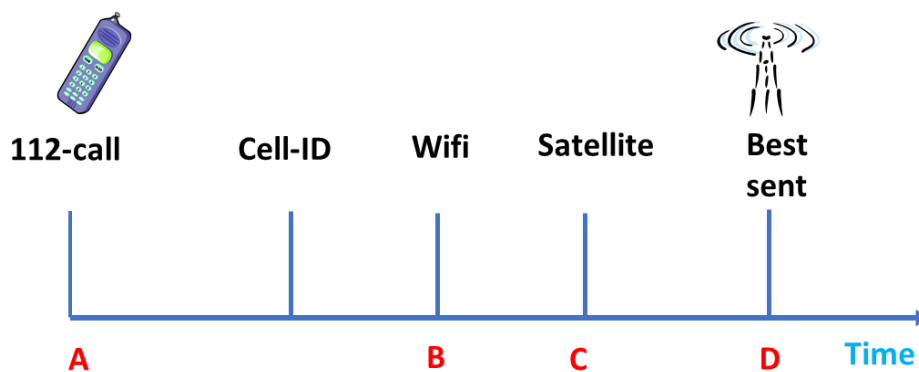
- GNSS
- Wifi

In AML the mobile terminal attempts to determine the best location as quickly as possible using all available methods not to delay the delivery of location information.

If GNSS data becomes available within a certain time this is sent.

If GNSS-information is not available quickly, Wifi SSID for adjacent access points is used and the registered Wifi-coordinates are retrieved to the terminal and are sent in the AML SMS.

The timeline below illustrates the process



<sup>11</sup> The temporary Calling Party Number is linked to the terminal in the HLR using the IMSI.



- A. If necessary mobile data Wifi and satellite location are turned on.
- B. When Wifi location is received, Wifi is turned off for saving battery.
- C. If satellite position is retrieved before a certain time it shall be sent. GNSS is now turned off.
- D. If GNSS is not available, Wifi or base station location information is sent. If no location information is available at all an empty SMS is sent<sup>12</sup>.

Below a description of the conveyance of location information in AML.



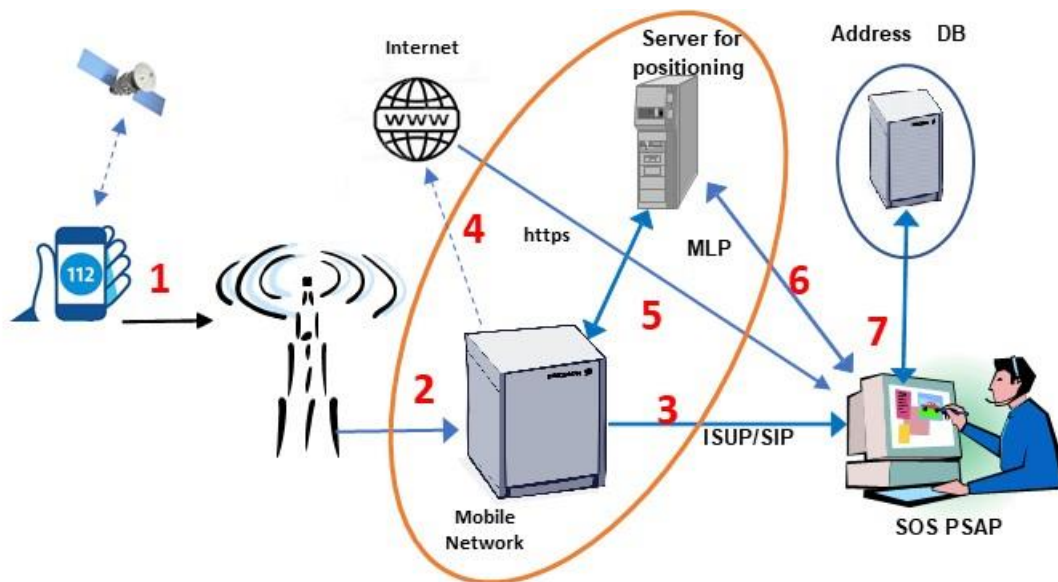
1. An emergency call is initiated.
2. The call and the AML SMS are connected through the public electronic communications network.
3. The call is connected to the PSAP.
4. The SMS is sent over the SMS Center (SMSC).
5. The SMS reaches SOS' system and is correlated to the incoming call based on telephone number.
6. Cell-ID (according to base station location) also reaches SOS.
7. Request is sent to the address database and registered address of the subscription is sent if this information is registered.

<sup>12</sup> Cell-ID location is always available in the Swedish communications network and sent according to chapter 11.



## 12. Location with SOS Alarm 112 Application

If the SIM-card is registered to the network and authenticated and the terminal has installed the SOS 112-app and allowed access to location data the procedure is described below.



1. An emergency call is initiated.
2. The call and the 112-app application data message are sent through the public electronic communication network.
  - a. The application data message requires data network connection.
3. The call is connected directly to the PSAP.
4. The application data message is sent over the data channel.
5. The application data message reaches SOS system and is correlated to the incoming call on the telephone number of the calling subscriber.
6. Cell-ID (according to base station location) also reaches SOS.
7. Request is sent to the address database and registered address for the subscription is sent if this information is registered.

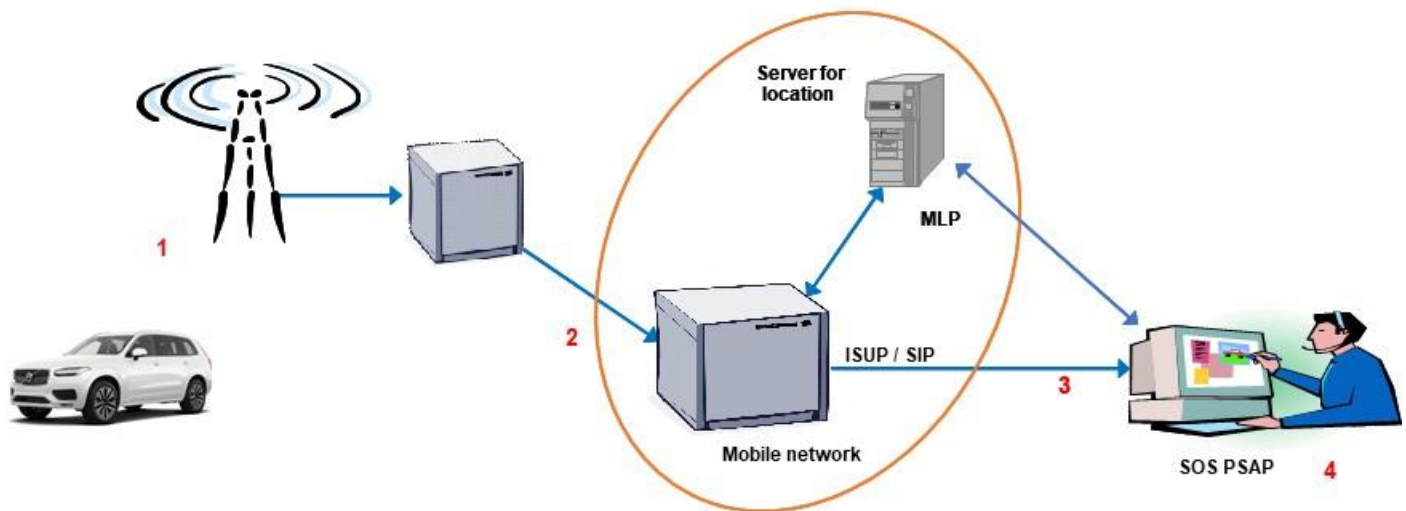
If the terminal has AML installed an AML SMS is also sent.

### 13. eCall

eCall is a manually or automatically initiated emergency call from a vehicle completed with a Minimum Set of emergency related Data (MSD) transferred from a modem in the vehicle.

When an eCall is triggered the Minimum Set of Data containing the following information is sent.

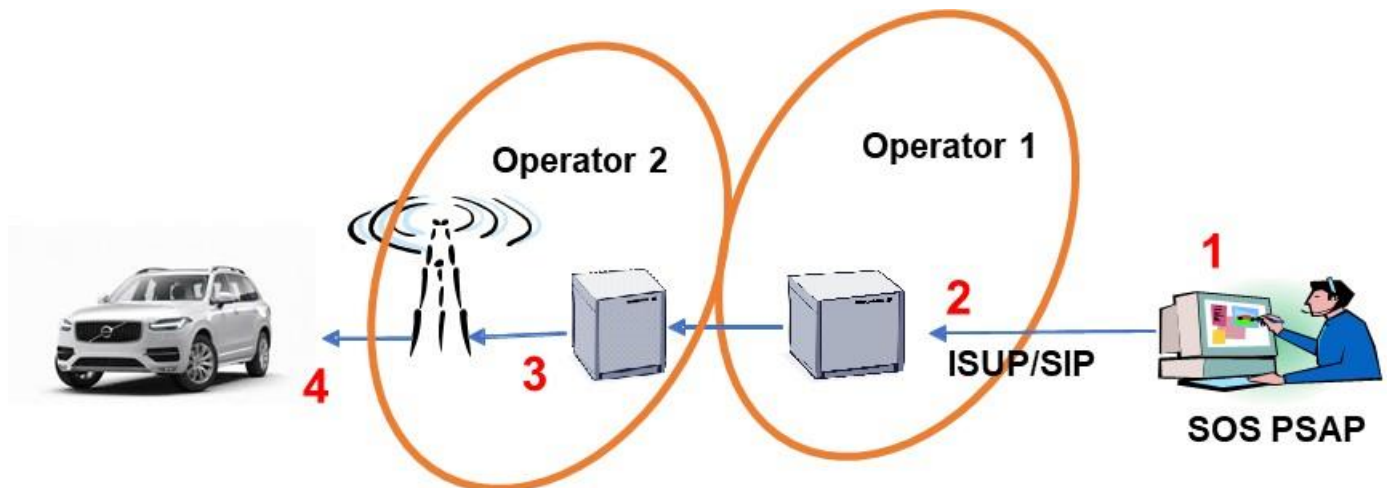
- Activation: If the eCall has been manually or automatically triggered
- Type of call: real emergency call or test call
- Type of vehicle
- Vehicle Identification Number (VIN)
- Fuel storage type
- Timestamp of the activation
- Vehicle location at accident
- Confidence of location
- Vehicle direction at accident
- Latest known vehicle location
- Number of passengers and safety belts
- Additional data



1. eCall is triggered (manually or automatically).
2. A speech channel is established.
  - a. First the MSD is transferred over the speech channel.
  - b. Then the channel is opened for speech.
3. The MSD reaches the PSAP.
4. The emergency call taker can see the received location information and the speech path is opened for talk between the emergency call taker and the person(s) in the car.

### 13.1. eCall call-back

The incoming call might be disconnected and the emergency call taker needs to call back to the vehicle to ask for information, e.g. on location. It is important that the telephone number range of the car is opened for incoming calls and that it is allowed for roaming. Thus, there must be a roaming agreement between the operator of the number range of the number the car has and the public electronic communications operator the call is made from.



#### Example

1. The emergency call taker initiates call back using the number received in the incoming 112 eCall.
  - This number may be allocated to any public electronic communications operator.
2. The outgoing operator used by SOS Alarm must allow traffic to the numbering range which the number belongs to.
3. The public electronic communications operator of the call origination must have a roaming agreement with the numbering range holder of the eCall subscriber, i.e. the car.
4. If these conditions are fulfilled the call is connected to the car.

These prerequisites are beyond control for SOS Alarm.

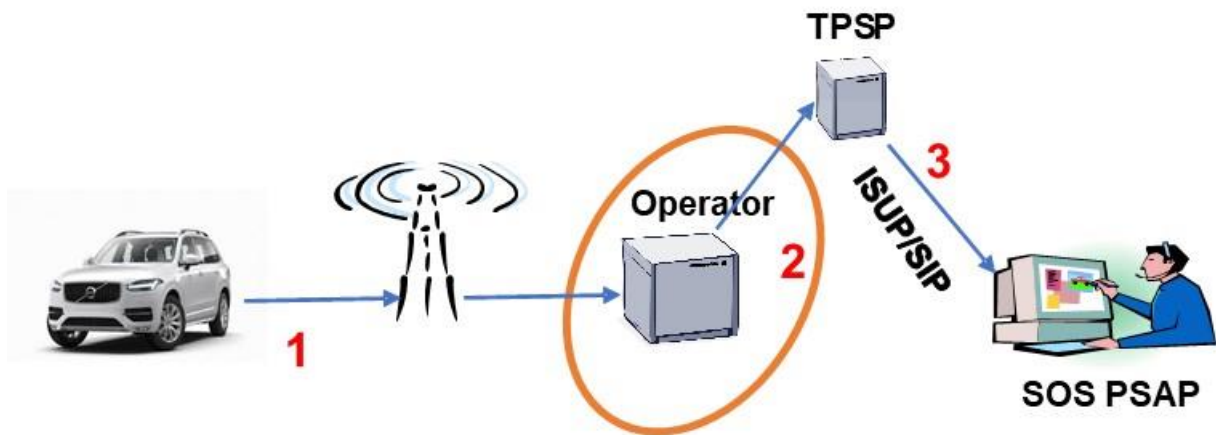
### 13.2. Third Party Service for eCall Service, TPS

The Pan European eCall uses the 112 number to send data and to establish the voice channel between the passengers of the vehicle and emergency services. Car manufacturers can also decide to contract a private eCall service supported by Third Party Service Providers (TPSP). In this case, the automatic or manually activated eCall arrives first to the Third Party Service Provider's call center and then, in case of real emergency, data and voice are forwarded to the most appropriate Public Safety Answering Point.

In Sweden, SOS has currently contracted three Third Party Service Providers, TPSP. Third Party eCall is sent from the vehicle to the TPSP which in its turn forwards the eCall with the TPS eCall Set of Data. This is done using a normal telephone number (not 112) assigned to specific PSAPs.

1. An TPS eCall is set up from a vehicle, automatic or manual.
2. The TPS call is set-up to the Third Party Service Provider with the TPS eCall Set of Data.
3. The TPS call is forwarded to the PSAP using a normal telephone number assigned to the PSAP.

This means that the incoming call is not recognized as an ordinary emergency call since the number used is not 112.

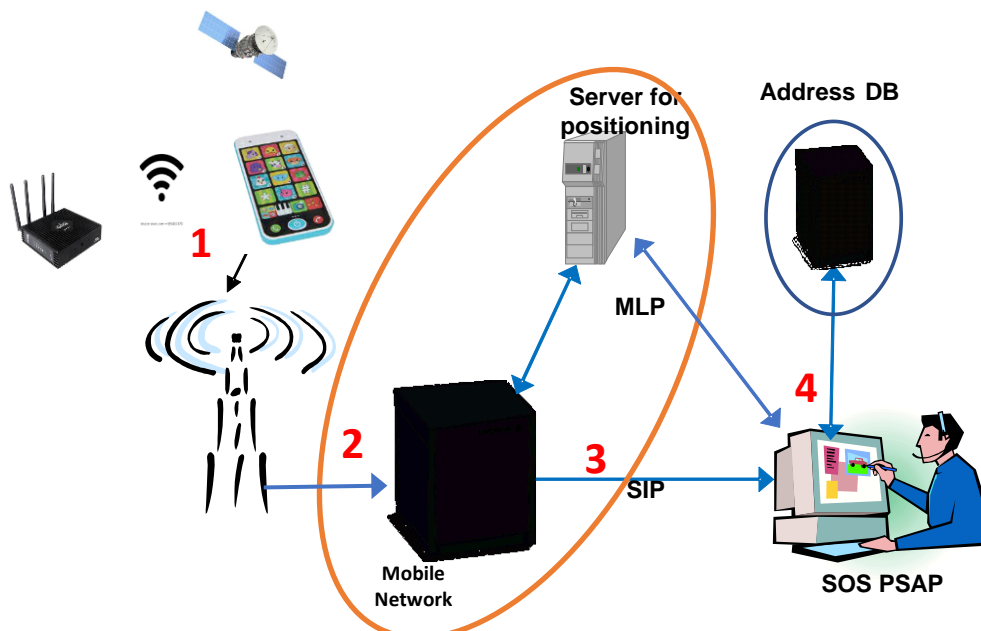


#### 14. Location in Call Set-Up

The interconnection between the public electronic communication networks [15] and SOS over IP facilitates conveyance of information in SIP. One function supported is Location Conveyance according to RFC 6442 [11].

The location information is sent from the calling terminal over SIP in the call set-up. The information is the coordinates of the location stored in the terminal or retrieved in connection with the establishment of the emergency call.

Below the call procedure.



1. An emergency call is initiated from a mobile terminal.
2. The call is set up from the radio network and through the public electronic communications network conveying location in the SIP signaling.
3. The call arrives to the PSAP and the location is displayed.
4. Base station location according to chapter 10 is also received.

## 15. Document history

Document history		
<b>Edition</b>	<b>Date of publication</b>	<b>Changes</b>
1	October 2021	First edition